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(54) Title: ENHANCED HERBICIDES

(57) Abstract: The invention provides, improved herbicide compositions, methods of making the compositions and methods of controlling plant growth. The subject invention relates to combining fatty acid based and other herbicides with succinic acid, succinic acid derivatives and other additives such as those having essentially no herbicidal activity to increase the activity of the herbicide and provide methods of controlling plant growth by applying a combination of a herbicidal fatty acid with succinic acid and/or succinic acid derivative chemicals and/or other additives. In addition to the use of succinic acid, combining other Krebs cycle acids with herbicides can also provide beneficial effects. Concentration of herbicides and additives applied to plants in accordance with the invention can include compositions involving 0.1 to 30 % herbicide, preferably 0.5 to 15 % herbicide and additive and more preferably 1-8 % herbicide. The ratio of herbicide, such as fatty acid herbicide to activity enhancing additives can be from 1:10 to 20:1, preferably 1:1 to 20:1, most preferably 1:1 to 5:1.

## ENHANCED HERBICIDES

### BACKGROUND OF THE INVENTION

The invention relates generally to herbicides, methods of improving existing herbicides and controlling the growth of plant life and more particularly to methods and products involving succinate-based chemicals and other additives which can enhance the activity (effectiveness) of herbicidal compounds. As used herein, herbicidal refers to materials which destroy or inhibit plant growth, such as by desiccation or defoliation, for example, to act as a harvest aid or to control weed growth.

Glyphosate and paraquat are the number 1 and 2 non-selective herbicides used worldwide. Paraquat is extremely toxic and therefore unacceptable for many applications. Glyphosate can be slow acting, commonly requiring 1 to 2 weeks to achieve plant death and is therefore also unsuitable for many herbicide applications.

Other conventionally known herbicides include fatty acids, such as pelargonic acid, a nine carbon fatty acid, and caprylic acid, an eight carbon fatty acid. Scythe, sold by Mycogen/Dow and Liberty, made by AgrEvo are known commercially available herbicides. Pelargonic acid is the active ingredient in Scythe and glufosinate-ammonium is the active ingredient in Liberty. However, the activity of these products is such that the cost of products such as Scythe can be undesirably high and the amount of active ingredients needed in products such as paraquat could lead to undesirable effects.

Accordingly, it is desirable to provide improved herbicides, methods for enhancing the activity of existing herbicides and methods of controlling plant growth in order to overcome inadequacies of the prior art.

### **SUMMARY OF THE INVENTION**

Generally speaking, in accordance with the invention, improved herbicide compositions, methods of making the compositions and methods of controlling plant growth are provided. The subject invention relates to combining fatty acid based and other herbicides with succinic acid, succinic acid derivatives and other additives such as those having essentially no herbicidal activity to increase the activity of the herbicide and provide methods of controlling plant growth by applying a combination of a herbicidal fatty acid with succinic acid and/or succinic acid derivative chemicals and/or other additives. In addition to the use of succinic acid, combining other Krebs cycle acids with herbicides can also provide beneficial effects. Concentrations of herbicides and additives applied to plants in accordance with the invention can include compositions involving about 0.1 to 30% herbicide and additive, preferably 0.5 to 15% herbicide and additive and more preferably 1-8% herbicide and additive. The ratio of herbicide, such as fatty acid herbicide to activity enhancing additive can be from about 1:10 to 20:1, preferably 1:1 to 20:1, more preferably 1:1 to 5:1.

Accordingly, it is an object of the invention to provide improved herbicidal compositions.

Another object of the invention is to provide additives which can enhance the activity of herbicidal compositions.

Yet another object of the invention is to improve the safety of herbicides.

A further object of the invention is to provide improved methods of plant control.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the compositions possessing the characteristics, properties and the relation of constituents useful to effect such steps, which will be exemplified in the compositions hereinafter described, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The invention is directed to improved herbicidal compositions. Herbicides, such as those including fatty acids as the active ingredient can be formulated at low fatty acid concentration and have relatively low herbicidal activity or at higher fatty acid concentration and have enhanced activity. However, it has been found that certain additives, such as organic acids and their derivatives, which may have substantially no herbicidal activity can enhance the herbicidal activity of herbicidal fatty acids and other herbicides and provide herbicides with either enhanced activity or reduced fatty acid concentrations. Preferred additives include those organic acids which are part of the Krebs cycle and in particular, succinic acid as well as succinic

acid derivatives. Thus, substantially safe non-herbicidal additives are combined with G.R.A.S. (generally recognized as safe by the FDA) herbicidal compounds such as fatty acids, and the result is a generally safe herbicide with enhanced activity.

The following examples demonstrate the synergistic relationship between additives (such as succinic acid) and fatty acid herbicides such as caprylic acid, pelargonic acid and others. Other synergistic relationships between organic acids (for example, citric acid, tartaric acid, malic acid and lactic acid) with caprylic acid as the fatty acid were also exhibited. In general, with the exception of tartaric acid, there was a general lack of correspondence between the acidity of the organic acid and the degree of synergy of the organic acid with caprylic acid. It was determined that tartaric acid (e.g. L-tartaric acid) exhibited particularly high performance enhancement of caprylic acid across a wide variety of plant types.

A synergistic relationship between succinic acid and sodium salicylate was also demonstrated where the effect of succinic acid alone on the plants treated was negligible.

Accordingly, it has been determined that combining certain organic acids and compounds having a significant herbicidal effect, such as pelargonic, caprylic, caproic, capric and oleic acid, and also such acids as acetic, butyric, valeric, hexanoic and heptanoic acid and compounds such as sodium salicylate, glyphosate (in Round Up) or glufosinate-ammonium with other organic acids and additives including those having substantially no herbicidal effect could enhance herbicidal activity and reduce costs, environmentally undesirable effects or be otherwise more convenient to use.

Effective additives include succinic acid and succinic acid derivatives such as dimethyl succinic acid, calcium succinate, magnesium succinate, diammonium succinate and ammonium succinate as well as certain other organic acids, such as tartaric acid, citric acid, malic acid, lactic acid, adipic acid and plant oils such as limonene and pine oil, especially Unipine (a pine oil derivative available from Busche, Boake & Allen, Inc.), as well as other additives including ammonium sulfate, ammonium tartrate, ammonium chloride and sodium salicylate.

In order to confirm that additives in accordance with the invention provided an enhanced herbicidal effect, a number of experiments were performed in which only fatty acids or other herbicides were applied to plants, the additives alone were applied and the fatty acids plus the additives were applied. The herbicides were applied in the "spray to drip" amount or at a calibrated 20-60 gallons/acre. "Spray to drip" is an uncalibrated application of fluid to foliage, where sufficient spray volume is used to sufficiently saturate the foliage surface until excess fluid begins to drip from the foliage. In general, about 5 to 200 gallons/acre, preferably 20-100 gallons/acre can be effective.

Fatty acids above 6-7 carbon atoms tend to be relatively insoluble in water. Caprylic and pelargonic acids are 8 and 9 carbon acids respectively and require a solvent, such as acetone or an emulsifier to help prevent separation between aqueous and lipid phases. Herbicides can be provided in concentrated form and then diluted at the point of use.

Aspects and embodiments of the invention will be described more clearly with reference to the following examples, which are intended to be interpreted as exemplary, and not in a limiting sense.

**Example 1****Potato field trial: two varieties (Snowden and Russet Burbank)  
Comparison of Desiccate II with experimental formulations****Average injury rating\* & (%vine injury) (days after 1<sup>st</sup> application)**

<b>Treatment:</b>	<b>Snowden</b>			<b>Russet Burbank</b>		
	<b>Day 5</b>	<b>Day 8</b>	<b>Day 15</b>	<b>Day 5</b>	<b>Day 8</b>	<b>Day 15</b>
1 Desiccate II (2.175 quart/acre)	0 (0)	30 (10)	100 (100)	50 (40)	60 (70)	100 (96)
2 4% pelargonic + 0.5% succinic acid	90 (70)	100 (94)	100 (100)	97 (90)	98 (95)	100 (100)
3 4% caprylic/capric + 0.5% succinic	90 (70)	96 (92)	100 (100)	95 (90)	98 (97)	100 (100)
4 4% caprylic/capric + 0.5% succinic + 1% sodium salicylate	90 (80)	100 (98)	100 (100)	95 (90)	96 (92)	100 (100)
5 4% sodium salicylate + 0.5% succinic	25 (0)	40 (10)	95 (90)	70 (60)	98 (92)	100 (100)
6 6% caprylic/capric + 0.5% succinic	95 (75)	100 (90)	100 (100)	80 (70)	98 (94)	100 (100)

\* Injury rating based on scale of 1-5, where 5 = complete desiccation of all plants/plot  
 Second application 5 days after 1<sup>st</sup> application; each at 87 G/a (45 psi)  
 Treatment #1 contained 0.125% Wilfarm Crop Oil Concentrate  
 Treatments #2-4 and 6 contained 0.83% Emsorb 6900, 0.43% mineral oil and 1% Hasten  
 Treatment #5 contained 0.3% Sylgard 309

**Summary: all experimental treatments (#2-6) better than treatment #1 (Desiccate II)**



**Example 2**

**Potato field trial: 2 applications of selected herbicides, including Desiccate II**

Treatment	Injury rating*, average per plot				
	Day 1	Day 2	Day 3	Day 4	Day 5
1 5% pelargonic	4.07	4	4.13	4.43	4.43
2 5% pelargonic + 1% di-ammonium succinate	4.23	4.23	4.47	4.57	4.57
3 5% caprylic/capric + 1% di-ammonium succinate	3.87	3.9	4.03	4.4	4.4
4 Desiccate II (1.5 quarts/acre)	1	1.5	1.67	3	3

\* Injury rating, based on a scale of 1-5, where 5= complete desiccation of all plants/plot  
1% Hasten in treatments 1, 2 and 3. For treatment 4: 0.125% Wilfarm Crop Oil Concentrate.  
Treatments 1, 2 and 3 also had 0.86% Emsorb 6900 and 0.43% mineral oil  
Plot size: 3X6 feet. Each treatment group had 3 replicates  
40-42 G/acre, with <45 psi for 1<sup>st</sup> application and 45 psi for 2<sup>nd</sup> application  
2<sup>nd</sup> treatment applied 2 days after 1<sup>st</sup> treatment  
Variety: Katahdin (thick canopy), with active growth (irrigated)  
Summary: 1) treatments 1-3 superior to treatment 4 (Desiccate II),  
2) pelargonic acid enhanced by di-ammonium succinate

**Example 3****Dry bean (navy) field trial: single application of selected herbicides, including Desiccate II**

<u>Treatment</u>	<u>Injury rating*, average per plot</u>					<u>% desiccation, day 14</u>		
	<u>Day 2</u>	<u>Day 4</u>	<u>Day 5</u>	<u>Day 6</u>	<u>Day 14</u>	<u>foliage</u>	<u>vines</u>	<u>pod</u>
1 Desiccate II (1.5 quarts/acre)	3.375	3.8	4.55	4.68	4.625	90	50	60
2 4% pelargonic + 0.5% succinic acid	4.325	4.35	4.7	4.73	4.763	98	90	97
3 4% caprylic + 0.5% succinic acid	4.413	4.43	4.76	4.83	4.8	98	90	97
4 4% sodium salicylate + 0.5% succinic	4.388	4.38	4.68	4.73	4.775	95	80	97

\*Injury rating, based on a scale of 1-5, where 5 = complete desiccation of all plants/plot

1% Hasten in treatments 2, 3 and 0.3% Sylgard 309 in treatment 4. Treatment 1 had 0.125% Wilfarm Crop Oil Concentrate

Treatments 2 and 3 also contained 0.86% Emsorb 6900 and 0.43% mineral oil

Plot size = 3 X 6 feet, with 4 replicates (plots) per treatment group

40 gallons per acre at 45 psi for one application

Dry bean variety (navy): Vista

Field

**Summary: Treatments 2-4 were superior to treatment 1 (Desiccate II)**

**Example 4****Bean (black) trial: single application of selected herbicides, including Desiccate II**

<b>Treatment:</b>	<b>Injury rating*, average per plot</b>				<b>Day 9</b>	<b>Day 19</b>	<b>foliage</b>	<b>% desiccation, day 19</b>	
	<b>Day 1</b>	<b>Day 3</b>	<b>Day 7</b>					<b>vines</b>	<b>Pods</b>
1 Desiccate II (1.5 quarts/acre)	1.75	4.35	4.5		4.7	4.88	97	99	100
2 3% caprylic + 0.5% succinic acid	4.3	4.55	4.55		4.7	4.9	99	99	100
3 3% pelargonic + 0.5% succinic acid	4.55	4.75	4.78		4.85	5	100	100	100
4 3% sodium salicylate + 0.5% succinic acid	4.5	4.7	4.7		4.83	5	100	100	100

\*Injury rating, based on a scale of 1-5, where 5 = complete desiccation of all plants/plot  
 1% Hastern in treatments 2, 3 and 0.3% Sylgard 309 in treatment 4. Treatment 1 had 0.125% Wilfarm Crop Oil Concentrate  
 Treatment 2 and 3 also contained 0.86% Emsorb 6900 and 0.43% mineral oil  
 Plot size: 3 X 6 feet, with 2 replicates (plots) per treatment group  
 40 gallons per acre at 45 psi for one application  
 Dry bean variety: black, T39  
 Field

**Summary: Treatments 2-4 superior to treatment 1**

**Example 5****Synergistic interactions of succinic acid and di-ammonium succinate with herbicidal compounds, on navy dry beans**

Treatment:	Injury rating*, average per plot					% desiccation (Day 12)		
	Day 1	Day 2	Day 3	Day 4	Day 12	foliage	vines	pods
1 3% caprylic	3.5	3.93	3.93	4	4.2	50	10	80
2 3% caprylic + 0.5% succinic acid	4.43	4.43	4.6	4.5	4.7	95	70	85
3 3% caprylic + 2% succinic acid	4.5	4.47	4.57	4.5	4.8	99	85	90
4 3% caprylic + 2.52% di-ammonium succinate	4.47	4.43	4.67	4.6	4.8	99	90	99
5 3% sodium salicylate	3.8	4.13	4.57	4.5	4.7	92	70	90
6 3% sodium salicylate + 0.5% succinic acid	3.93	4.27	4.63	4.6	4.8	95	85	92
7 3% sodium salicylate + 2% succinic acid	4.2	4.4	4.67	4.6	4.9	97	80	95
8 3% sodium salicylate + 2.52% di-ammonium succinate	4.4	4.43	4.72	4.6	4.9	97	90	95
9 0.5% succinic acid	0	0	0	0	0	0	0	0
10 2% succinic acid	0	0	0	0	0	0	0	0
11 2.52% di-ammonium succinate	0	0	0	0	0	0	0	0
12 0.5% succinic acid	0	0	0	0	0	0	0	0
13 2% succinic acid	0	0	0	0	0	0	0	0
14 2.52% di-ammonium succinate	0	0	0	0	0	0	0	0

\*Injury ratings, based on a scale of 1-5, where 5 = complete desiccation of all plants/plot

Treatments 1-4, 9-11: each in 0.86% Emorb 6900, 0.43% mineral oil, 1% Hasten

Treatments 5-8, 12-14: each in 0.3% Sylgard 309

Succinic (2%) and di-ammonium succinate (2.52%) are equimolar

Plot size: 3 X 6 feet. Each treatment group had 3 replicates

One application at 40 G/acre, 45 psi

Variety: dry bean (navy Vista)

Field

Summary: both succinic acid and di-ammonium succinate were synergistic with sodium salicylate and caprylic acid

**Example 6****Synergistic interactions of succinic acid and di-ammonium succinate with other herbicidal compounds, on dry beans (black)**

Treatment:	Injury rating*, average per plot		% desiccation (Day 12)		
	Day 2	Day 12	foliage	vines	Pods
1 3% caprylic	4	4.73	80	92	95
2 3% caprylic + 0.5% succinic acid	4.37	4.87	97	95-98	90
3 3% caprylic + 2% succinic acid	4.43	4.92	99	98	97
4 3% caprylic + 2.52% di-ammonium succinate	4.37	4.9	99	95-97	85
5 3% sodium salicylate	4	4.78	95	90	90
6 3% sodium salicylate + 0.5% succinic acid	4.23	4.87	99	98	92
7 3% sodium salicylate + 2% succinic acid	4.07	4.88	99	95	90
8 3% sodium salicylate + 2.52% di-ammonium succinate	4.37	4.8	99	92	80
9 0.5% succinic acid	0	0	0	0	0
10 2% succinic acid	0	0	0	0	0
11 2.52% di-ammonium succinate	0	0	0	0	0
12 0.5% succinic acid	0	0	0	0	0
13 2% succinic acid	0	0	0	0	0
14 2.52% di-ammonium succinate	0	0	0	0	0

\*Injury ratings, based on a scale of 1-5, where 5 = complete desiccation of all plants/plot

Treatments 1-4, 9-11: each in 0.86% Emsorb 6900, 0.43% mineral oil, 1% Hasten

Treatments 5-8, 12-14: each in 0.3% Sylgard 309

Succinic (2%) and di-ammonium succinate (2.52%) are equimolar

Plot size: 3 X 6 feet. Each treatment group had 3 replicates

One application at 40 G/acre, 45 psi

Variety: black beans (dry bean variety T39)

**Summary: both succinic acid and di-ammonium succinate were synergistic with sodium salicylate and caprylic acid**

**Example 7****Enhancement of caprylic acid/sodium salicylate as an herbicide, by succinic acid**

<u>Treatment</u>	Succinic acid (%)	Relative injury rating* (average, based on 2 ratings)		
		potatoes	All plants	
1 0.25% caprylic + 0.25% sodium salicylate	0	3	8.5	
2 0.25% caprylic + 0.25% sodium salicylate	0.5	5	17	
3 0.25% caprylic + 0.25% sodium salicylate	1	6	17.6	
4 0.25% caprylic + 0.25% sodium salicylate	1.5	7.7	19.7	
5 0.25% caprylic + 0.25% sodium salicylate	2	6.8	18.9	
6 0.5% caprylic + 0.5% sodium salicylate	0	4.8	15.1	
7 0.5% caprylic + 0.5% sodium salicylate	0.5	5.3	17.7	
8 0.5% caprylic + 0.5% sodium salicylate	1	5.5	19.7	
9 0.5% caprylic + 0.5% sodium salicylate	1.5	7	21.3	
10 0.5% caprylic + 0.5% sodium salicylate	2	7.5	22.1	

\* A rating of 1-5 given (5= complete desiccation of all plants), for each treatment (1-2 plants/pot)

Two independent evaluations (ratings) performed

Helena Kinetec at 0.2% used for all treatments

All formulations in 30% acetone

**Spray to drip applications to dry beans, snapbeans and potato plants**

**Example 8****Effect of 1% succinic acid on herbicidal activity of Liberty and Scythe**

Treatment	Total score for all injury ratings*
1 4% Scythe	66
2 2% Scythe	54.2
3 2% Scythe + 1% succinic	56.1
4 2% Scythe + 0.25% caprylic + 0.25% sodium salicylate	56.3
5 2% Scythe + 0.25% caprylic + 0.25% sodium salicylate + 1% succinic	60.3
6 2% Scythe + 0.5% sodium salicylate	47.5
7 Liberty (4oz/gal)	87.8
8 Liberty (2oz/gal)	76.6
9 Liberty (2oz/gal) + 1% succinic	81
10 Liberty (2oz/gal) + 0.25% caprylic + 0.25% sodium salicylate	77
11 Liberty (2oz/gal) + 0.25% caprylic + 0.25% sodium salicylate + 1% succinic	78.4
12 Liberty (2oz/gal) + 0.5% sodium salicylate	75.7
13 Liberty (1oz/gal)	65.9
14 Liberty (1oz/gal) + 1% succinic	70.3
15 Liberty (1oz/gal) + 0.25% caprylic + 0.25% sodium salicylate	67.6
16 Liberty (1oz/gal) + 0.25% caprylic + 0.25% sodium salicylate + 1% succinic	72.1
17 Liberty (1oz/gal) + 0.5% sodium salicylate	70.8

\*Injury rating based on 1 to 6, where 6= complete desiccation of plant. Six independent evaluations performed and all scores, based on ratings for nutsedge, snapbeans and Kentucky bluegrass, were given as a total score for each treatment

Kinetic at 0.2% used for all treatments. Applications of treatments made via spray to drip. Snapbeans (full bean production), nutsedge (6-8 inches, height) and bluegrass (blade height 3 inches)

1% succinic acid = zero rating. Succinic was synergistic with those combinations given above.

**Example 9**

**Enhancement of RoundUp Ultra's herbicidal activity on snapbeans and potatoes using 1% succinic acid**

Treatment	Average injury rating*	
	potatoes	snapbeans
1 RoundUp Ultra, 1.25%	4.48	2.92
2 RoundUp Ultra, 1.25% + 1% succinic acid	4.67	4.78
3 RoundUp Ultra, 0.25%	3.35	2.82
4 RoundUp Ultra, 0.25% + 1% succinic acid	4.37	3.2

\*Rating of 1 to 6 = complete desiccation

Average rating based on 6 independent evaluations of injury to plants

Application rate of 1.25% RoundUp Ultra at 40 G/acre = 2 quarts/acre

(0.25% RoundUp Ultra at 40G/acre= 0.4 quarts/acre)

Mature snapbeans (with beans pods) and potatoes at 6-8 inches in height were used

**Summary: succinic acid synergistic with RoundUp**



Example 10

Succinic acid enhancement of herbicidal activities:  
sodium salicylate +/- caprylic acid

Treatment	Injury rating*	
	<u>Spray to drip</u>	<u>Average rating per pot</u>
1 0.75% caprylic + 0.75% sodium salicylate	45.1	2.82
2 0.75% caprylic + 0.75% sodium salicylate + 1% succinic acid	60.3	3.77
3 1% caprylic + 1% sodium salicylate	50.1	3.13
4 1% caprylic + 1% sodium salicylate + 1% succinic acid	61.1	3.82
5 1.5% sodium salicylate	56.2	3.51
6 1.5% sodium salicylate + 1% succinic acid	62.5	3.91

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
Three independent evaluations were done  
Test plants for spray to drip application: Kentucky bluegrass, velvetleaf, foxtail, tomato, potato and snapbeans  
All spray solutions contained 30% acetone and 0.3% Sylgard 309  
Caprylic acid was v/v and succinic acid and sodium salicylate were at wt/v  
**Summary: Succinic acid enhanced effectiveness**

Example 11Enhancement of herbicide formulations with 1% succinic acid

<u>Treatment</u>		<u>Average injury rating</u>
1	0.5% caprylic + 0.5% sodium salicylate	31.6
2	0.5% caprylic + 0.5% sodium salicylate	41.4
3	0.5% caprylic + 0.5% sodium salicylate	41.6
4	0.5% caprylic + 0.5% sodium salicylate	39.2
5	0.5% caprylic + 0.5% sodium salicylate	46.8
6	0.5% caprylic + 0.5% sodium salicylate	44.6
7	0.5% caprylic + 0.5% sodium salicylate	43.6
8	0.5% caprylic + 0.5% sodium salicylate	40
	0.5% ammonium chloride	
	0.5% ammonium chloride	
	1% succinic acid	
	1% succinic acid	
	1% succinic acid	

\*A rating of 1-5, where 5 = complete desiccation of all plants  
 Three independent evaluations (ratings) performed  
 Helena Kinetic at 0.1% used for all applications  
 All formulations in 30% acetone  
 Spray to drip applications to snapbeans and potato plants

**Example 12**

**Succinic acid enhancement of herbicidal activities:  
sodium salicylate combined with hexanoic, acetic or caprylic/capric acid**

<u>Treatment</u>	<u>Injury rating*</u>	
	<u>Spray to drip</u>	<u>Average rating per pot</u>
1 2% hexanoic + 1% sodium salicylate	44.1	3.68
2 2% hexanoic + 1% sodium salicylate + 1% succinic	55.8	4.65
3 3% acetic + 1% sodium salicylate	47.1	3.93
4 3% acetic + 1% sodium salicylate + 1% succinic	54.4	4.53
5 2% caprylic/capric + 1% sodium salicylate	50	4.17
6 2% caprylic/capric + 1% sodium salicylate + 1% succinic	54.4	4.53
7 2% caprylic/capric + 1% sodium salicylate + 2% succinic	56.7	4.73

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
Two independent evaluations were done

Test plants for spray to drip application: velvetleaf, corn snapbeans, foxtail and tomatoes  
All spray solutions contained 30% acetone and 0.3% Sylgard 309

Acetic, hexanoic and caprylic/capric acid were v/v and succinic acid was wt/v

Caprylic/capric (caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively).

**Example 13**

**Succinic acid enhancement of oleic acid/sodium salicylate herbicidal activity**

<u>Treatment</u>	<u>Injury rating*</u>	
	<u>Spray to drip</u>	<u>Average rating per pot</u>
1 2% oleic acid	26.4	2.2
2 2% oleic acid + 1% sodium salicylate	37.9	3.16
3 2% oleic acid + 1% sodium salicylate + 1% succinic acid	49.2	4.1
4 2% oleic acid + 1% succinic acid	28.1	2.33

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
Two independent evaluations were done  
Test plants for spray to drip: lambsquarter, velvetleaf, foxtail, nutsedge and potatoes  
All spray solutions contained 50% acetone and 0.3% Sylgard 309  
Oleic acid was v/v and succinic acid and sodium salicylate was wt/v  
**Summary: Sodium salicylate and succinic acid enhance effectiveness**

**Example 14****Succinic acid enhancement of oleic acid/sodium salicylate herbicidal activity**

Treatment	Total Injury rating*			Average rating per pot
	60 G/a	Spray to drip	Total	
1 2% oleic acid	23.5	22.3	45.8	1.91
2 2% oleic acid + 1% sodium salicylate	52.3	34.7	87	3.63
3 2% oleic acid + 1% sodium salicylate + 1% succinic acid	63.8	37.1	101	4.2

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants Both 60 gallons/acre and spray to drip applications were made.

Two independent evaluations for both 60 G/a and spray to drip applications

Test plants for 60 G/a: lambsquarter, foxtail and velvetleaf

Test plants for spray to drip: snapbeans, corn and tomatoes

All spray solutions contained 50% acetone and 0.3% Sylgard 309

Oleic acid was v/v and succinic acid and sodium salicylate was wt/v

**Example 15**

**Cotton desiccation: comparison of Scythe with formulations containing caprylic/capric, sodium salicylate and succinic acid**

Treatment	Average rating* Three evaluations			Average rating for all 3 evaluations
	1	2	3	
1 2% caprylic + 1% sodium salicylate	4	3.5	3.6	3.7
2 2% caprylic + 1% sodium salicylate	3.8	4.1	4	3.97
3 2% caprylic + 1% sodium salicylate	4.2	4.5	4.4	4.4
4 2% Scythe (1.2% active ingredients)	2	2	2	2
5 4% Scythe (2.4% active ingredients)	3.4	3.2	3.3	3.27

\* rating based on visual injury rating of 1-5, where 5 = complete desiccation of cotton foliage

Cotton variety = DeltaPine NuCotn 33-b

All treatments (except Scythe) in 30% acetone

Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively, i.e.

Henkel's Emery 658, used at v/v, in water

Applications at 60 gallons/acre

**Example 16****Herbicide activity of caprylic acid/sodium salicylate +/- succinic acid**

<u>Treatment</u>	<u>Total injury rating*</u>
1 1% caprylic + 3% sodium salicylate + 0.5% succinic	97.7
2 3% caprylic + 1% sodium salicylate + 0.5% succinic	97.9
3 1% caprylic + 3% sodium salicylate + 1.5% succinic	97.9
4 3% caprylic + 1% sodium salicylate + 1.5% succinic	99.9
5 1% caprylic + 3% sodium salicylate	79.8
6 3% caprylic + 1% sodium salicylate	91.3

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants Both 60 gallons/acre and spray to drip applications were made.

Two independent evaluations for both 60 G/a and spray to drip applications

Test plants for 60 G/a: lambsquarter, foxtail and Kentucky bluegrass

Test plants for spray to drip: nutsedge, foxtail and velvetleaf

All spray solutions contained 30% acetone and 0.3% Hasten

Caprylic acid was v/v and succinic acid and sodium salicylate were wt/v

**Example 17****Herbicidal activity of caproic acid with other compounds:  
succinic acid and sodium salicylate**

<u>Treatment</u>	<u>Total injury ratings*</u>			<u>Spray to drip</u>	<u>Total score</u>
	<u>60 G/a</u>				
1 2% caproic	11.2			7.3	18.5
2 2% caproic + 1% succinic	13.8			7.6	21.4
3 2% caproic + 2% succinic	12.7			7.1	19.8
4 3% caproic	13.9			7	20.9
5 3% caproic + 1% succinic	14.1			7.9	22
6 3% caproic + 2% succinic	14.5			8.2	22.7
7 2% caproic + 1% sodium salicylate	13.5			8.7	22.2
8 2% caproic + 1% sodium salicylate + 1% succinic	16.7			9.2	25.9

\*For 60 G/a: 4 pots/treatment, testing lambsquarter, pigweed and velvetleaf

\*For spray to drip: 2 pots/treatment, testing lambsquarter and foxtail

For each pot (2-20 plants/pot), a rating of 1-5 given, where 5 was complete desiccation of all plants

All solutions included 1% Emsorb 6900 and 0.3% Hasten

**Summary: sodium salicylate and succinic acid enhance effectiveness**



**Example 18****Herbicidal activity of caprylic acid combined with other compounds  
(i.e., salts of succinate +/- sodium salicate)**

<u>Treatment</u>	<u>Total injury ratings*</u>			<u>Total score</u>
	<u>60 G/a</u>	<u>Spray to drip</u>		
1 2% caprylic	61	8.2		69.2
2 2% caprylic + 1.5% diammonium succinate	67.9	8.8		76.7
3 2% caprylic + 1.5% potassium succinate	58	7.6		65.6
4 2% caprylic + 1.5% sodium salicylate	63.7	7.8		71.5
5 2% caprylic + 1.5% sodium salicylate + 1.5% diammonium succinate	70	8.6		78.6
6 2% caprylic + 1.5% sodium salicylate + 1.5% potassium succinate	58.9	7.5		66.4

\*For 60G/a: 8 total pots/treatment, testing lambsquarter, pigweed, velvetleaf and foxtail

\*For spray to drip: 2 total pots/treatment, testing velvetleaf and foxtail

Evaluations made: 2 for plants treated at 60 G/a and 1 evaluation for "spray to drip"

For each pot (2-20 plants/pot), a rating of 1-5 given, where 5 was complete desiccation of all plants

All treatments included 1% Emsorb 6900

Example 19

Efficacy of caprylic with succinic or ammonium succinate, as herbicides in an emulsification system (Emsorb 6900)

Injury rating*, total score for 2 evaluations				
Treatment	60 G/a	Spray to drip	Total Rating	Average rating per pot
1 2% caprylic	73.6	49.8	123.4	4.11
2 2% caprylic + 1.5% ammonium succinate	76.1	54.5	130.6	4.35
3 2% caprylic + 3% ammonium succinate	76.4	57.7	134.1	4.47
4 2% caprylic + 1.5% succinic acid	80.6	52.4	133	4.43

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
Two independent evaluations done for both 60 G/a and spray to drip  
Test plants for 60 G/a: black nightshade, redroot pigweed, lambsquarter, foxtail, velvetleaf and snapbeans  
Test plants for spray to drip: redroot pigweed, lambsquarter, velvetleaf and foxtail  
All spray solutions contained 1% emsorb (Henkel) and 0.3% Hasten  
Caprylic acid was at v/v and succinic acid and ammonium succinate were at wt/v

**Example 20**

**Efficacy of caprylic with succinic or ammonium succinate, as herbicides  
in an emulsification system (Emsorb 6900)**

**Injury rating\*, total score  
for 2 evaluations**

<u>Treatment</u>	<u>60 G/a</u>	<u>Spray to drip</u>	<u>Total Rating</u>	<u>Average rating per pot</u>
1 3% caprylic	142	36.6	178.4	4.05
2 3% caprylic + 0.5% ammonium succinate	145	37.5	182.2	4.14
3 3% caprylic + 1.5% ammonium succinate	145	39.8	185	4.2
4 3% caprylic + 1.5% succinic acid	151	44.6	195.9	4.45

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
Two independent evaluations done for both 60 G/a and spray to drip  
Test plants for 60 G/a: black nightshade, redroot pigweed, foxtail, lambsquarter and snapbeans  
Test plants for spray to drip: redroot pigweed, velvetleaf, nutsedge and foxtail  
All spray solutions contained 1% emsorb (Henkel) and 0.3% Hasten  
Caprylic acid was at v/v and succinic acid and ammonium succinate were at wt/v

**Example 21**

**Efficacy of 1.5% succinic acid with oleic, caprylic or pelargonic acid, as herbicides in an emulsification system (Emsorb 6900)**

Treatment	Injury rating*, total score for 2 evaluation			Average rating per pot
	60 G/a	Spray to drip	Total Rating	
1 3% oleic	24.2	9.4	33.6	1.2
2 3% oleic + 1.5% succinic	27.3	8.7	36	1.29
3 3% caprylic	88.1	35.4	123.5	4.41
4 3% caprylic + 1.5% succinic	91.5	37.5	129	4.61
5 3% pelargonic	85.3	37.6	122.9	4.39
6 3% pelargonic + 1.5% succinic	91.2	37.4	128.6	4.59

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants

Two independent evaluations done for both 60 G/a and spray to drip

Test plants for 60 G/a: velvetleaf, black nightshade, redroot pigweed, foxtail and snapbeans

Test plants for spray to drip: black nightshade, velvetleaf, foxtail and snapbeans

All spray solutions contained 1% Emsorb (Henkel) and 0.3% Hasten

Oleic, caprylic and pelargonic at v/v and succinic acid at wt/v

**Succinic acid, alone, had a rating of zero. Succinic acid was synergistic with oleic, caprylic and pelargonic acids**

Example 22

Efficacy of caprylic + sodium salicylate + succinic acid, as an herbicide in an emulsification system (Emsorb 6900)

Treatment	Injury rating*, total score for 2 evaluation			Average rating per pot
	60 G/a	Spray to drip	Total Rating	
1 2% caprylic + 1.5% succinic	58.5	62	120.5	3.08
2 2% caprylic + 1.5% succinic + 1% sodium salicylate	65	64.1	129.1	3.31
3 3% caprylic + 1.5% succinic	68.7	68.1	136.8	3.51
4 3% caprylic + 1.5% succinic + 1% sodium salicylate	72	71.1	143.1	3.67
5 4% caprylic + 1.5% succinic	71	66.6	137.6	3.53

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants  
 Two independent evaluations done for both 60 G/a and spray to drip  
 Test plants for 60 G/a: redroot pigweed, velvetleaf, snapbeans, cotton and potatoes  
 Test plants for spray to drip: black nightshade, lambsquarter, foxtail and snapbeans  
 All spray solutions contained 1% Emsorb (Henkel) and 0.3% Hasten  
 Caprylic acid was at v/v and succinic acid and sodium salicylate were at wt/v  
 Succinic acid, alone, had a rating of zero. Succinic acid was synergistic with oleic, caprylic and pelargonic acids

**Example 23****Herbicidal activity: relationships between caprylic acid and succinic acid +/- ammonium sulfate**

Treatment	Total Injury ratings, combined, for two separate evaluations*			
	60 G/a	Spray to drip	Total Rating	Average rating/pot
1 4% caprylic acid	60.7	56.1	116.8	4.49
2 4% caprylic acid + 0.5% succinic acid	63.9	57	120.9	4.65
3 4% caprylic acid + 1% succinic acid	61.6	55.6	117.2	4.51
4 4% caprylic acid + 2% succinic acid	59.4	57.4	116.8	4.49
5 4% caprylic acid + 0.5% succinic acid + ammonium sulfate	60.4	56.6	117	4.5
6 4% caprylic acid + 1% succinic acid + ammonium sulfate	64	57.8	121.8	4.68
7 4% caprylic acid + 2% succinic acid + ammonium sulfate	62.1	57.4	119.5	4.6

\*For 60 G/a: 7 total pots/treatment, testing redroot pigweed, foxtail and velvetleaf

For spray to drip: 6 total pots/treatment, testing foxtail, dry beans and pigweed

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete desiccation of all plants

Two independent evaluations (ratings) done for plants treated at both 60 G/a and spray to drip

All treatments included Emsorb 6900 (Henkel) at 1%

Caprylic acid and succinic acid, as v/v and wt/v, respectively, in water

**Succinic acid, alone, had a rating of zero. Caprylic acid + succinic acid was synergistic**

**Example 24****Herbicidal activity: comparison of fatty acids, when combined with succinic acid and sodium salicylate**

<u>Treatment</u>	<u>pH, spray solution</u>	<u>60 G/a</u>	<u>Total Injury ratings, combined, for two separate evaluations*</u>		<u>Average rating/pot</u>
			<u>Spray to drip</u>	<u>Total</u>	
1 3% butyric acid + succinic/NaSal	3.8	102.3	52.5	154.8	4.3
2 3% valeric acid + succinic/NaSal	3.9	105	53.8	158.8	4.41
3 3% caproic acid + succinic/NaSal	4.4	104.9	51.9	156.8	4.36
4 3% heptanoic acid + succinic/NaSal	4.5	108.9	54.1	163	4.53
5 3% caprylic acid + succinic/NaSal	4.5	112.4	55.5	167.9	4.67
6 3% pelargonic acid + succinic/NaSal	4.5	111.9	56.6	168.5	4.68
7 3% oleic acid + succinic/NaSal	4.5	105	53.2	158.2	4.39
8 3% caprylic/capric + succinic/NaSal	4.6	114.3	57.3	171.6	4.77

\*For 60 G/a: 12 total pots/treatment, testing redroot pigweed, wheat, foxtail and velvetleaf

For spray to drip: 6 total pots/treatment, testing redroot pigweed, foxtail and velvetleaf

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete desiccation of all plants

Two independent evaluations (ratings) done for plants treated at both 60 G/a and spray to drip

All treatments included 0.3% Hasten

Fatty acids at v/v and succinic acid (1%) and sodium salicylate (1%) at wt/v, in water

Caprylic/capric: caprylic, capric, caproic and lauric at 58, 40, 1 and 1% respectively (per Henkel Corporation)

No apparent correlation between pH of spray solutions (including Hasten) and herbicidal activity.

**Example 25**

**Synergistic relationships between 5% caprylic/capric (c/c) and succinic acid: desiccation of cotton plants**

<b><u>Average Rating</u></b>	<b><u>Average percent of foliage desiccated</u></b>	<b><u>Treatment</u></b>
2	20	
4	70	0.5% succinic and
4	60	1% succinic and
4	70	2% succinic and
		5% c/c
		5% c/c
		5% c/c
		5% c/c

\* Average rating based on 1-5, where 5 = complete desiccation of foliage

Test plant: DeltaPine NuCotn 33-b, open boll

c/c = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e., Henkel's Emery 658, used at v/v, in water

All treatments contained 1% Emsorb 6900

Treatment of plants with succinic acid, alone, had a rating of zero caprylic/capric and succinic at these concentrations were synergistic



**Example 26****Synergistic relationships between 5% caprylic/capric (c/c) and succinic acid**

Average rating: degree of plant damage (1-5, where 5 = complete desiccation)		<u>Treatment Ingredients</u>	
60 G/acre	Spray to drip		
4.14	4.61		5% c/c
4.33	4.83	0.5% succinic and	5% c/c
4.43	4.82	1% succinic and	5% c/c
4.41	4.71	2% succinic and	5% c/c

Test plants: cotton (DeltaPine NuCotn 33b), potatoes (Snowden), pigweed, sudan grass, wheat, foxtail, dry beans and velvetleaf  
 c/c = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e., Henkel's Emery 658, used at v/v, in water  
 All treatments contained 1% Emsorb 6900

Treatment of plants with succinic acid, alone, had a rating of zero  
**Caprylic/capric (c/c) and succinic acid were synergistic**

**Example 27**

**Synergistic relationship between caprylic/capric (c/c) and succinic acid, as harvest aids for potatoes and cotton**

**Treatment Ingredients**

Average rating: degree of plant damage  
(1-5, where 5 = complete desiccation)

**Average, 2 evaluations**

<u>Cotton</u>	<u>Potatoes</u>	
3.75	4.1	8% c/c
4.35	4.25	0.5% succinic and 8% c/c
4.65	4.15	1% succinic and 8% c/c
4.65	4.35	2% succinic and 8% c/c

Cotton (DeltaPine NuCotn 33b) and potatoes (Snowden) were at full maturity

Application volume/acre was 40 G/a

C/C = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e., Henkel's Emery 658, used at v/v, in water

Treatment of plants with succinic acid, alone, had a rating of zero

**Caprylic/capric (C/C) and succinic acid is synergistic**

**Example 28****Herbicidal activities: synergy between succinic acid and pelargonic acid**

Treatment	<u>Total injury ratings*</u>			Spray to drip	Total
	40 G/a	60 G/a			
1 4% pelargonic acid	41.6	45.6		66.2	153.4
2 4% pelargonic acid + 0.5% succinic acid	42.8	46.7		66.3	155.8
3 0.5% succinic acid	0	0		0	0

\*For 40 G/a: 9 total pots/treatment, testing crab grass, pigweed, chick weed and foxtail

\*for 60 G/a: 10 total pots/treatment, testing pigweed, Kentucky bluegrass, foxtail, crab grass and barnyard grass

\*For spray to drip: 7 total pots/treatment, testing Kentucky bluegrass, pigweed, barnyard grass, foxtail and velvetleaf

For each pot (2-20 plants/pot), a rating of 1-5 given, where 5 was complete desiccation of all plants  
All treatments included 1.125% Emsorb 6900 (v/v)

Example 29Synergistic relationships with caprylic/capric acids (c/c)

<u>Average relative injury rating*</u>		<u>Treatment Ingredients</u>	
<u>60 G/acre</u>	<u>Spray to drip</u>	<u>Average rating per pot</u>	<u>Compound (1%)</u>
4.5	4.57	4.52	3% c/c
4.49	4.59	4.54	3% c/c
4.56	4.33	4.45	3% c/c
4.46	4.33	4.4	3% c/c
4.62	4.5	4.58	3% c/c
4.53	4.52	4.53	3% c/c
4.56	4.47	4.52	3% c/c
4.6	4.61	4.61	3% c/c

\*For 60 G/a: 10 total pots/treatment, testing lambsquarter, pigweed, foxtail and barnyard grass

\*For spray to drip: 5 total pots/treatment, testing pigweed, sudan grass, foxtail, barnyard grass and velvetleaf

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants c/c = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e., Henkel's Emery 658, used at v/v, in water

**Example 30**

**Herbicidal activity on cotton foliage: synergistic relationships between succinic acid and caprylic/capric acid (c/c) combinations**

<u>Treatment</u>		Total injury ratings, combined, for two separate evaluations*	
		<u>60 G/a</u>	<u>Average rating/pot</u>
1	4% c/c	18.5	3.08
2	4% c/c + 0.5% succinic acid	21.4	3.57
3	5% c/c	22.4	3.73
4	5% c/c + 0.5% succinic acid	25.7	4.28
5	6% c/c	25.3	4.22

\*For 60 G/a: 3 total pots/treatment, testing cotton (DeltaPine NuCotn 33b)

For each pot, a rating of 1-5 was given, where 5 was complete desiccation of all foliage

Two independent evaluations (ratings) completed

All treatments included Emsorb 6900 (Henkel) at 1%

Caprylic/capric (caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively),

Henkel's Emery 658, used at v/v, in water

Since succinic acid tested alone had a rating of zero, caprylic/capric + succinic acid was synergistic

Herbicidal activity: 5% c/c + 0.5% succinic acid > 6% c/c

**Example 31**

**Herbicidal activities: synergistic relationships between succinic acid and caprylic/capric acid (c/c) combinations**

Treatment	Total injury ratings, combined for two separate evaluation*			Average rating per pot
	60 G/a	Spray to drip	Total Rating	
1 4% c/c	123.3	41.5	164.8	4.12
2 4% c/c + 0.5% succinic acid	128.1	45.1	173.2	4.33
3 5% c/c	129.9	46.3	176.2	4.41
4 5% c/c + 0.5% succinic acid	134.5	46.5	181	4.53
5 6% c/c	133.9	46.8	180.7	4.52

\*For 60 G/a: 10 total pots/treatment, testing nightshade, pigweed, foxtail barnyard grass, sudan grass and cotton (DeltaPine NuCotn 33b)

\*For spray to drip: 5 total pots/treatment, testing Kentucky bluegrass, nutsedge, barnyard grass, sudan grass and foxtail

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete desiccation of all plants

Two independent evaluations (ratings) done for plants treated at both 60 G/a and spray to drip

All treatments included Emsorb 6900 (Henkel) at 1%

Caprylic/capric (caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively), Henkel's Emery 658, used at v/v, in water

**Since succinic acid, alone had a rating of zero, caprylic/capric + succinic acid was synergistic**

**Example 32**

General screening of candidate compounds: to examine for synergistic relationships with caprylic/capric acids (c/c)

Average relative injury rating*			Treatment Ingredients	
40 G/acre	60 G/acre	Spray to drip	Average rating per pot	Compound (equimolar amounts)
4.21	4.43	4.44	4.35	
4.35	4.47	4.54	4.44	succinic acid (1%)
4.35	4.49	4.61	4.47	ammonium succinate (1.26%)
4.36	4.42	4.4	4.4	ammonium sulfate (1.12%)
4.35	4.5	4.59	4.47	ammonium tartrate (1.42%)
				3% c/c
				3% c/c
				3% c/c
				3% c/c
				3% c/c

\*For 40 G/a: 10 total pots/treatment, testing chickweed, lambsquarter, Kentucky bluegrass, redtop and rye

\*For 60 G/a: 10 total pots/treatment, testing giant and green foxtail, pigweed and crabgrass

\*For spray to drip: 7 total pots/treatment, testing Kentucky bluegrass, nutsedge, pigweed, Johnson grass, foxtail and sudan grass  
For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants  
c/c = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e.,  
Henkel's Emery 658, used at v/v, in water

**Example 33****Herbicidal activity: storage stability of fatty acid/succinic acid-based formulations**

Formulations stored one week (average day and night time temperatures were 90 and 75 degrees, Fahrenheit, in the greenhouse) and re-tested, via spray to drip applications on same test plant varieties

4% caprylic, 4% caprylic/capric and 4% pelargonic (+/- 0.5% succinic acid) were tested or a total of 6 formulations, each containing 1.125% Emsorb 6900 (Henkel)

Average scores, for all 6 formulations  
(rating per pot, 2-20 plants/pot)

	<u>Before storage</u>	<u>After storage</u>
Barnyard grass	4.73	4.8
Foxtail	4.68	4.68

A rating of 1-5 was given, where 5 was complete desiccation of all plants

Fatty acids were v/v and succinic acid was wt/v, in water

**Note: ratings for individual fatty acid treatments (+/- succinic acid), before and after storage, were similar**



**Example 34**

**Herbicidal combinations of caprylic/capric (c/c) or pelargonic acid, with equimolar amounts of succinic acid and ammonium succinate, on weed varieties**

Treatment	Total Injury ratings*			Spray to drip	Total	Average rating/pot
	40 G/a	60 G/a	60 G/a			
1 3% c/c	85.5	60.2	60.2	36.1	181.8	4.33
2 3% c/c + 1% succinic acid	88.1	62.5	62.5	36.7	187.3	4.46
3 3% c/c + 1.26% ammonium succinate	88.8	60.8	60.8	37.4	187	4.45
4 3% pelargonic acid	87.7	60.8	60.8	37.3	185.8	4.42
5 3% pelargonic acid + 1% succinic acid	865.9	62.2	62.2	38	187.1	4.45
6 3% pelargonic acid + 1.26% ammonium succinate	87.6	61.2	61.2	36.9	185.7	4.42

\*For 40 G/a: 10 total pots/treatment, testing crab grass, chickweed and common lambsquarter

\*For 60 G/a: 7 total pots/treatment, testing redtop, pigweed, foxtail

For spray to drip: 8 total pots/treatment, testing barnyard grass, foxtail, sudan grass and nutsedge

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete desiccation of all plants

Two independent evaluations for both 40 and 60 G/a and one evaluation for spray to drip

All treatments included Emsorb 6900 (Henkel) at 1%

Caprylic/capric (caprylic, capric, caproic and lauric at 58, 40, 1 and 1% respectively), i.e.,

Henkel's Emery 658, used at v/v, in water

Amounts of succinic acid and ammonium succinate used were equimolar amounts

Since succinic acid (or ammonium succinate) tested alone had a rating of zero, pelargonic acid (or c/c) + succinic acid (or ammonium succinate) were synergistic. The exception was: 3% pelargonic acid + 1.26% ammonium succinate

**Example 35**

**Enhancement of RoundUp Ultra (+/- ammonium sulfate or Ams) herbicidal activity, using succinic acid amendments**  
**RoundUp Ultra at 1 pint/acre (No Sylgard or any other surfactant used)**

		Days after treatment: relative injury ratings*			Average rating per pot
		Day #6	Day #9	Day #11	
1	RU	10.5	17.1	15.9	17.5
2	RU + ams	18.3	17.6	18.4	21.6
3	RU + ams + 0.5% succinic acid	21	20.3	24.3	25.7
4	RU + ams + 1.5% succinic acid	19.4	18.6	24.2	27.3
5	RU + 0.5% succinic acid	16.7	14.2	16	20.5
6	RU + 1.5% succinic acid	16.8	16.1	18.6	23.6

\*8 total pots/treatment, testing Kentucky bluegrass, barnyard grass, crab grass, pigweed, redtop, nutsedge, wheat and foxtail. For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants

RoundUp Ultra was at 1 pint/acre and ammonium sulfate, when used, was at 2%

Spray application at 60 G/acre

Succinic acid tested alone had a rating of zero. RoundUp Ultra, alone or RoundUp Ultra + ammonia sulfate were synergistic with succinic acid

**Example 36**

**Enhancement of RoundUp Ultra (+/- ammonium sulfate or Ams) herbicidal activity, using succinic acid amendments**  
**RoundUp Ultra at 1 pint/acre**

Treatment	Days after treatment: relative injury ratings*				Average rating per pot
	Day #6	Day #9	Day #11	Day #14	
1 RU	29	30.2	31.5	29.8	3.35
2 RU+ams	30.8	32.9	34.7	32.5	3.64
3 RU+ams + 0.5% succinic acid	30.2	32.7	35.5	34.5	3.69
4 RU+ams + 1.5% succinic acid	34.6	35.7	37.8	37.4	4.04
5 RU + 0.5% succinic acid	32.8	33.9	35.1	35.4	3.81
6 RU + 1.5% succinic acid	32.5	31.2	32.6	32.5	3.58

\*9 total pots/treatment, testing barnyard grass, green foxtail, sudan grass and pigweed. For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants. RoundUp Ultra was at 1 pint/acre and ammonium sulfate, when used, was at 2% Sylgard 309 (0.3%) added immediately before spray application at 60 gallons/acre. Succinic acid tested alone had a rating of zero. RoundUp Ultra, alone or RoundUp Ultra + ammonium sulfate were synergistic with succinic acid.

**Example 37**

**Enhancement of RoundUp Ultra (+/- ammonium sulfate or Ams) herbicidal activity, using succinic acid amendments**  
**RoundUp Ultra (RU) at 1 quart per acre**

Treatment	Days after treatment: relative injury ratings*					Average rating per pot
	Day #5	Day #8	Day #10	Day #13	Day 17	
1 RU	32.7	29.9	28.6	29.5	31.4	3.8
2 RU+ams	33.3	33.6	30.7	34.5	36.6	4.22
3 RU+ams + 0.5% succinic acid	34	34.5	32.4	35.3	36.7	4.32
4 RU+ams + 1.5% succinic acid	35.3	35.6	32.5	35.3	38.4	4.43
5 RU + 0.5% succinic acid	33.8	30.9	30.3	31	33.1	3.98
6 RU + 1.5% succinic acid	33.7	30.2	31	33.6	34	4.06

\*8 total pots/treatment, testing sudan grass, green foxtail, barnyard grass and pigweed  
 For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants  
 RoundUp Ultra was at 1 quart/acre and ammonium sulfate, when used, was at 2%, wt/v  
 Sylgard 309 (0.3%) added immediately before spray application at 60 gallons/acre  
 Succinic acid tested alone had a rating of zero. RoundUp Ultra, alone or RoundUp Ultra + ammonium sulfate were synergistic with succinic acid

Example 38Enhancement of herbicidal activity of RoundUp Ultra/ammonium sulfate testing selected amendments

Treatment	pH, spray solution	Days after treatment: injury ratings*				average per test
		day #4	day #7	day #11	day #13	
1 RU/ams	4.51	32.3	44.1	50	50.8	44.3
2 RU/ams+succinic acid	1.77	39.3	46.3	50.7	51.4	46.9
3 RU+ams+ammonium succinate	3.71	36.2	46.2	51.3	52.3	46.5
4 RU+ams ammonium tartrate	4.78	35.7	46	49.3	50.2	45.3
5 RU/ams+tartaric acid	1.27	33.9	46.9	50.7	51.5	46.2
6 RU/ams+citric acid	1.38	34.6	46.7	50.7	51.4	45.7
7 RU/ams+L-malic acid	1.59	34.6	47.7	51.1	51.8	46.3
8 RU/ams+acetic acid	2.51	33.7	47.1	50.8	51.3	45.7

\*11 total pots/treatment, testing velvetleaf, crab grass, sudan grass, redtop, green foxtail and barnyard grass.

For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete desiccation

Equimolar amounts of amendments used: 1.5% succinic acid, 1.89% ammonium succinate, 2.17% ammonium tartrate, 1.91% tartaric acid, 2.45% citric acid, 1.71% L-malic acid, 0.77% acetic acid

RoundUp Ultra (1.5 pints/acre) and 2% ammonium sulfate (ams) used in all treatments

Sylgard (0.3%) added immediately before spray application at 60 gallons/acre

Amendments used independently had a rating of zero. All amendments had a synergistic relationship with RU/ams; i.e.,

each amendment enhanced RU/ams herbicidal activity over ratings for RU/ams (containing no amendments).

No apparent correlation between pH of spray solutions (including Sylgard) and herbicidal activity was found.

**Example 39**

**Enhancement of herbicidal activity of caprylic/capric acids (c/c),  
using selected compounds at equimolar amounts**

Treatment	Days after treatment: relative injury ratings*				Average rating per pot
	Day #2	Day #4	Day #5		
1 3% c/c	30	27.6	30.3		3.66
2 3% c/c + succinic acid (1%)	35.8	33.6	35.1		4.35
3 3% c/c + di-ammonium succinate (1.26%)	35.1	32.5	34.2		4.24
4 3% c/c + ammonium sulfate (1.12%)	35.5	33.6	34.4		4.3
5 3% c/c + ammonium tartrate (1.42%)	35.9	33.6	34.2		4.32
6 succinic acid (1%)	0	0	0		0
7 di-ammonium succinate (1.26%)	0	0	0		0
8 ammonium sulfate (1.12%)	0	0	0		0
9 ammonium tartrate (1.42%)	0	0	0		0

\*8 total pots/treatment, testing chickweed, redtop, velvetleaf, crabgrass and green foxtail  
For each pot (2-20 plants/pot), a rating of 1 to 5 given, where 5 was complete injury/desiccation of all plants  
All treatments included 0.86% Emsorb 6900 and 0.43% mineral oil  
c/c = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1% respectively; i.e.,  
Henkel's Emery 658, used at v/v, in water  
Application volume was 40 G/acre  
Synergistic relationships exist between 3% c/c and each amendment tested

**Example 40****Desiccation of cotton foliage: Interaction of RoundUp Ultra and caprylic acid/capric acid (+/- succinic acid)**

Treatment	Day after treatment: average rating*								Total Rating
	1	2	5	7	10	12	17	26	
1 RU + 2% AMS	0	0	6	6	7	7			
2 RU + 2% AMS 4% C/C	18	16	15	15	15	16			95.9
3 RU + 2% AMS 4% C/C + 1% succinic acid	18	17	17	17	16	18			103.2
4 RU + 2% AMS 1% succinic acid	0	0	7.2	6.5	7.7	8.8			30.2
5 2% AMS 4% C/C + 1% succinic acid	18	17	18	17	18	17			105.4
6 2% AMS 4% C/C	18	17	18	18	18	17			104.8

\*Visual rating of 1 to 5, where 5= complete desiccation of all cotton plants (4 plants per treatment group, each plant receiving a rating of 1-5)

Cotton variety = DeltaPine NuCotn 33b, at open boll, when treated

RoundUp Ultra at 1 quart/acre delivered at 60 G/a

Each treatment contained 1.14% Emsorb 6900 and 0.57% mineral oil

Caprylic/capric (caprylic, capric, caproic and lauric at 58, 40, 1 and 1% respectively), i.e.,

Henkels, Emery 658, used at v/v, in water

AMS = ammonium sulfate

Succinic acid had a rating of zero.

Combination of succinic acid with other ingredients was synergistic.

**Example 41****Synergistic relationship between succinic acid and caprylic/capric acids C/C, relating to herbicidal activity**Injury ratings based on 2 independent evaluations\*

Treatment	40 G/a	60 G/a	Total	Average rating per pot
1 4% caprylic/capric	87.3	80.7	168	4.42
2 4% caprylic/capric + 1% succinic	88.6	82.1	170.7	4.49
3 4% caprylic/capric + 0.5% succinic	89.9	82.7	172.6	4.54
4 4% caprylic/capric + 0.5% succinic + 0.5% sodium salicylate	90.3	82.6	172.9	4.55
5 0.5% succinic acid	0	0	0	0
6 0.5% sodium salicylate	1	0.5	1.5	0.04
7 5% caprylic/capric	92	82.8	174.8	4.6
8 5% caprylic/capric + 0.5% succinic acid	91.6	83.9	175.5	4.62

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants

Two independent evaluations were made for both 40 and 60 gallons/acre applications

For 40 G/acre: Canadian thistle, velvet leaf, Johnson grass and giant foxtail

For 60 G/acre: velvetleaf, Johnson grass and giant foxtail were tested

C/C = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively; i.e.,

Henkel's Emery 658, used at v/v, in water

Succinic acid and sodium salicylate were added at wt/volume

All treatments included Henkel's Emery 6900 and mineral oil; i.e., for each 1% of caprylic/capric, 0.286 and 0.143% of 6900 and mineral oil were included in each treatment



**Example 42****Herbicidal activity: comparison of caprylic, pelargonic and an equimolar mixture of caprylic and pelargonic acids**

<u>Injury ratings based on 2 independent evaluations*</u>			
<u>Treatments (equimolar comparison)</u>			<u>Average rating per pot</u>
	<u>40 G/acre</u>	<u>60 G/acre</u>	
1 3% caprylic	40.8	51.6	4.16
2 3.375% pelargonic	43	53.6	4.41
3 1.5% caprylic + 1.69% pelargonic	43	53.6	4.41
4 4% caprylic	44.1	54.5	4.49
5 4.5% pelargonic	45.1	53.9	4.51
6 2% caprylic + 2.25% pelargonic	44.6	54.2	4.51

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants

For 40 G/acre: chickweed, redroot pigweed, lambsquarter and green foxtail were tested

For 60 G/acre: chickweed, redroot pigweed, lambsquarter, green foxtail, crabgrass and wheat were tested

Caprylic and pelargonic acids were used at volume/volume

All treatments included Henkel's Emisorb 6900 and mineral oil: for each 1% of caprylic or pelargonic acid, 0.286 and 0.143% of 6900 and mineral oil were included in each treatment.

**Example 43****Herbicidal enhancement of pelargonic by succinic acid and diammonium succinate**

<u>Injury ratings based on 2 independent evaluations*</u>					
<u>Treatment</u>	<u>40 G/a</u>		<u>60 G/a</u>		<u>Average rating per pot</u>
	<u>Spray to drip</u>		<u>Spray to drip</u>		
1 2.5% Scythe active ingredients	78.7	103	53.6	4.36	
2 2.5% pelargonic	79.2	102.2	53.8	4.36	
3 2.5% pelargonic + 0.5% succinic	81.7	105.1	55.3	4.48	
4 2.5% pelargonic + 2% succinic	80.2	105.5	55.1	4.46	
5 2.5% pelargonic + 2% diammonium succinate	80.9	105.4	54.4	4.46	
6 2.22% caprylic/capric (C/C)	80.3	103.4	51.5	4.36	

\*For each pot, a rating (1 to 5) was given, where 5 was complete desiccation of all plants

40 G/a: lambsquarter, velvetleaf and green foxtail were tested

60 G/a: pigweed, chickweed, crabgrass, green foxtail, velvetleaf, lambsquarter and wheat were tested

Spray to drip: nutsedge, velvetleaf, green foxtail, giant foxtail and barnyard grass were tested

C/C = Caprylic, capric, caproic and lauric at 58, 40, 1 and 1%, respectively, i.e.,

Henkel's Emery 658, used at v/v, in water

The active ingredients in Scythe, (pelargonic acid) and caprylic/capric (Henkel's Emery 658) were compared on equimolar basis

**Example 44****Synergistic Relationship between Succinic or Citric acid and Caprylic Acid, Testing Dry Beans  
Treatment effects 3 days after single, foliar application**

<u>Treatment</u>	<u>Green Foliage</u>		<u>Yellow Foliage</u>	
	<u>Overall Effect</u>	<u>Foliage Affected (%)</u>	<u>Overall Effect</u>	<u>Foliage Affected (%)</u>
Na Salicylate (2%)	5	90	5	>90
Na Salicylate (0.5%)	2	5-10	1	30
Na Salicylate (0.5%) + Citric Acid (0.5%)	1	5-10	1	30
Na Salicylate (0.5%) + Succinic Acid (0.5%)	1.5	5-10	1	>40
Citric Acid (0.5%)	0	0	0	0
Succinic Acid (0.5%)	0	0	0	0
Caprylic Acid (0.5%)	2.5	10-15	2	70
Caprylic Acid (0.5%) + Citric Acid (0.5%)	3.5	30	3	90
Caprylic Acid (0.5%) + Succinic Acid (0.5%)	4	50	4	>90

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)

Dry bean variety = Vista

Citric acid and succinic acid showed synergistic effect

**Example 45**

**Greater Effect by Succinic Acid over Calcium Succinate,  
when used with Sodium Salicylate, Testing Several Plant Varieties\***

<b><u>Treatments</u></b>	<b>overall effect, 9 evaluations (average)</b>
Sodium Salicylate (1%) + Succinic Acid (1%)	2.89
Sodium Salicylate (1%) + Calcium Succinate (1%)	1.44

Overall effect: higher score = greater effect  
(where 5 equals profound desiccation)

\*Test plants: weed varieties, shrub foliage, covergrass, turf and soybeans

**Example 46**

Confirmation of Example 45, Testing Turf and Shrub Foliage  
Treatment effects 1, 2, 4 and 7 days after a single, foliar application

<u>Treatments</u>	Overall effect, 17 evaluations <u>(average)</u>
Sodium Salicylate (1%)	1.35
Sodium Salicylate (1%) + Succinic Acid (2%)	2.59
Sodium Salicylate (1%) + Calcium Succinate (2%)	2.18
Succinic Acid (2%)	0.24

Overall effect: higher score = greater effect  
(where 5 equals profound desiccation)

Succinic acid and calcium succinate showed synergistic effect

**Example 47****Effects of desiccants and desiccant combinations with other compounds on young potato plants**

Treatment #	Ingredients	Injury ratings of treated plants (hours or days after application)						All evaluations (total score)
		1.5 hr	1	3	6	17	22	27
1	1% caprylic	2	2	3	2	2.5	3	3
2	1% caprylic + 0.5% tartaric + 0.5% NaSal	3	5	5.5	5	5.5	5.5	4
3	1% caprylic + 1% tartaric	2	3	3.5	3	3.4	4	3
4	1% caprylic + 0.5% dimethyl succinic acid	2	3	3	3	3	3.5	3
5	1% caprylic + 0.5% beta-alanine	1	2	2	2	2.5	3	2.5
6	1% caprylic + 1% succinic	3	4	3	4	5	5.5	4.5
7	2% caprylic	3.5	5	5	5	5	5.5	5.5
8	2% caprylic + 0.5% tartaric + 0.5% NaSal	4.5	6	6	6	6	6	6
9	sodium salicylate	3.5	5	5	5	5	5.5	5.5
	2% caprylic + 1% tartaric							

Caprylic acid and dimethyl succinic acid added v/v; all other compounds added at wt/v.

All solutions in 50% acetone, with solution (20 mls) sprayed 2 feet from plant canopy. Helena Kinetic at 0.2% included in each solution. All plants grown in green house (day time temp= 80-100 degrees, Fahrenheit)

Higher evaluation scores represent greater degree of vine and foliage desiccation. A "6" = complete desiccation.

Summary: a) addition of succinic or tartaric acid to 1% caprylic acid > 1% caprylic acid, (b) combination of NaSal + tartaric (or succinic acid) to caprylic acid were the best treatments

**Example 48**

**Synergistic Relationships Between:  
Succinic Acid + Caprylic Acid  
Succinic Acid + Sodium Salicylate**  
Treatment effects 3 days after a single, foliar application, testing soybeans

Treatment	Overall Effect	Foliage Affected (%)
Caprylic Acid (1%)	2.5	25-30
Caprylic Acid (1%) + Succinic Acid (1%)	3	30-35
Succinic Acid (1%)	0	0
Sodium Salicylate (1%)	1.5	15-20
Sodium Salicylate (1%) + Succinic Acid (1%)	3.5	40-50

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation  
Soybean variety = Stine 2250

**Example 49****Enhancement of Scythe's herbicidal activity by selected compounds**

Independent evaluations of snapbean and potato plants,  
hours/days after application of desiccants

Treatment #	Treatment Ingredients	1.5 hours		2 days		11 days		15 days	
		beans	potatoes	beans	potatoes	beans	potatoes	beans	potatoes
1	2% NaSalicylate	1	0	1	1	1.5	1	1	1
2	4% Scythe	3	3	3.5	2.5	2	2	1	2
3	4% Scythe + 2% NaSal	4	3	5	3.5	3	3	2	3
4	4% Scythe + 0.25% tartaric	4	3	4	3	2.5	2.5	3	2
5	4% Scythe + 0.5% tartaric	4	4	5.5	3	3	2	4	1.5
6	4% Scythe + 1% tartaric	4	3.5	6	3.5	3	3	3	2
7	4% Scythe + 1% NaSal	3	3	4.5	3	2.5	2.5	2	2
8	4% Scythe + 0.5% NaSal	3	3	4.5	2	1.5	1.5	1	1.5
9	4% Scythe + 1% caprylic	4	4.5	5	3.5	2	3.5	1	3.5
10	4% Scythe + 0.5% tartaric + 0.5% NaSal	4	5	5.5	5	3.5	4	3	5
11	4% Scythe + 1% citric acid	4	3	6	3	2.5	2	2	2

**Totals, all evaluations**

	Beans		Potatoes		All
	1	2	3	4	
1	4.5	3	7.5		
2	9.5	9.5	19		
3	14	12.5	26.5		
4	13.5	10.5	24		
5	16.5	10.5	27		
6	16	12	28		
7	12	10	22		
8	10	8	18		
9	12	15	27		
10	16	19	35		
11	145	10	24.5		

Solutions applied at 40 gallons/acre, containing 0.1% Helena Kinetic. All plants grown in greenhouse (day temperature was 80-100 degrees, fahrenheit). Higher rating scores represent greater degree of desiccation. A "6" = complete desiccation. Scythe and caprylic acid added v/v. All other compounds added wt/v.

**Summary:** a) all combinations with Scythe (except 0.5% NaSal) improved performance, b) best combination was 4% Scythe with 0.5% tartaric + 0.5% NaSal, c) increasing the concentration of tartaric acid with 4% Scythe had little effect



**Example 50**

**Synergistic Relationships Between Succinic Acid and Caprylic Acid  
at Different Application Rates, Testing Soybeans  
Treatment effects 2 days after a single, foliar application**

	Overall Effect	Two Independent Sites (average of 2 sites)	Foliage Affected (%)
Caprylic Acid (0.2%)	0.5		1.25
Caprylic Acid (0.5%)	2.25		9
Caprylic Acid (1.0%)	4		22.3
Caprylic Acid (0.2%) + Succinic Acid (1.0%)	1.5		6.5
Caprylic Acid (0.5%) + Succinic Acid (1.0%)	3		15
Caprylic Acid (1.0%) + Succinic Acid (1.0%)	4.25		26
Succinic Acid (1.0%)	0		0
Caprylic Acid (0.5%) + L - Lactic Acid (1.0%)	2.75		15
L-Lactic Acid (1.0%)	0.5		1.25

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)  
Soybean variety = Stine 2250

**Succinic acid and lactic acid had synergistic effect**

**Example 51****Synergy Comparisons of Various Organic Acids with Caprylic Acid, Testing Soybeans****Treatment effects 3 days after a single, foliar application**

<u>Treatments</u>	<u>Two Independent Sites</u> (average of 2 sites)	
	<u>Overall Effect</u>	<u>Foliage Affected (%)</u>
Caprylic Acid (0.5%)	1.5	5
Caprylic Acid (0.5%) + L-Tartaric Acid (0.5%)	2.75	17.5
Caprylic Acid (0.5%) + L-Malic Acid (0.5%)	2	11.5
Caprylic Acid (0.5%) + Succinic Acid (0.5%)	2.25	12.5
Caprylic Acid (0.5%) + L-Lactic Acid (0.5%)	2.25	11.5
Caprylic Acid (0.5%) + Citric Acid (0.5%)	2.75	17.5
L-Tartaric Acid (0.5%)	0	0
L-Malic Acid (0.5%)	0	0
Succinic Acid (0.5%)	0	0
L-Lactic Acid (0.5%)	0	0
Citric Acid (0.5%)	0	0

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)  
Soybean variety = Stine 2250

**Tartaric, malic, succinic, lactic and citric acid showed synergistic effects**

### Example 52

**Synergistic Relationships Between Succinic Acid and Caprylic Acid (or Sodium Salicylate), Testing Turf**

**Treatment effects 2 days after a single, foliar application**

<u>Treatments</u>	<u>Overall Effect</u>
Caprylic Acid (1.0%)	2
Caprylic Acid (1.0%) + Succinic Acid (0.5%)	3
Succinic Acid (0.5)	0
Sodium Salicylate (1.0%)	1.5
Sodium Salicylate (1.0%) + Succinic Acid (0.5%)	2

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)

**Example 53**

**Effects of Various Compounds on Caprylic Acid  
Testing Turf and Covergrass  
Treatment effects 1, 3, 6, 7 and 11 days after a single,  
foliar application at two, independent sites**

Treatments	Overall Effect 10 Evaluations (average)
Caprylic Acid (1.0%)	2.45
Caprylic Acid (1.0%) + Adipic Acid (0.5%)	2.6
Caprylic Acid (1.0) + L-Tartaric Acid (0.5%)	3.8
Caprylic Acid (1.0%) + Unipine (0.5%)	3.45
Caprylic Acid (1.0%) + Sodium Salicylate(0.5%)	3.1

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)

**Adipic acid, tartaric acid, unipine and sodium salicylate showed synergistic effects**

**Example 54****Effects of Various Compounds on Caprylic Acid  
Testing Turf and Shrub Foliage****Treatment effects 3, 4, 6 and 7 days after a single, foliar application**

<u>Treatments</u>	Overall Effect 29 Evaluations (average)
Caprylic Acid (1.0%)	1.05
Caprylic Acid (1.0%) + Adipic Acid (0.5%)	2.19
Caprylic Acid (1.0) + L-Malic Acid (0.5%)	1.4
Caprylic Acid (1.0%) + L-Tartaric Acid (0.5%)	2.19
Caprylic Acid (1.0%) + Unipine (0.5%)	2.4
Caprylic Acid (1.0%) + Sodium Salicylate(0.5%)	2.05
Caprylic Acid (1.0%) + Succinic Acid (0.5%)	1.95
Caprylic Acid (1.0%) + L-Lactic Acid (0.5%)	2.16
Caprylic Acid (1.0%) + Citric Acid (0.5%)	1.47

Overall effect: higher scores = greater effect  
(where 5 equals profound desiccation)

**Adipic acid, tartaric acid, unipine, sodium salicylate, succinic acid, lactic acid and citric acid showed synergistic effects**

**Example 55****Measurement of pH Values for Test Desiccants**

	pH Value
Caprylic Acid (0.5%)	3.30
Caprylic Acid (0.5%) + L-Tartaric Acid (0.5%)	1.07
Caprylic Acid (0.5%) + L-Malic Acid (0.5%)	1.49
Caprylic Acid (0.5%) + Succinic Acid (0.5%)	1.67
Caprylic Acid (0.5%) + L-Lactic Acid (0.5%)	1.69
Caprylic Acid (0.5%) + Citric Acid (0.5%)	1.51
L-Tartaric Acid (0.5%)	1.52
L-Malic Acid (0.5%)	1.69
Succinic Acid (0.5%)	1.94
L-Lactic Acid (0.5%)	1.93
Citric Acid (0.5%)	1.64
Caprylic Acid (0.5%)	3.55
Caprylic Acid (0.5%) + Succinic Acid (0.5%)	1.77
Succinic Acid (1.0%)	1.85
Sodium Salicylate (1.0%)	5.63
Sodium Salicylate (1.0%) + Succinic Acid (0.5%)	2.9
Caprylic Acid (1.0%)	3.93
Caprylic Acid (1.0%) + Adipic Acid (0.5%)	2.69
Caprylic Acid (1.0%) + L-Malic Acid (0.5%)	2.17
Caprylic Acid (1.0%) + L-Tartaric Acid (0.5%)	2.07
Caprylic Acid (1.0%) + Unipine 90 (0.5%)	4.06
Caprylic Acid (1.0%) + Sodium Salicylate (0.5%)	4.29

**Example 56****Measurement of pH Values for Test Desiccants**

	pH Value
Sodium Salicylate (0.5%)	4.48
Sodium Salicylate (0.5%) + Succinic Acid (1.0%)	2.76
Sodium Salicylate (0.5%) + Succinic Acid (1.0%) + Caprylic Acid (0.5%)	2.78
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%)	4.2
Succinic Acid (1.0%) + Caprylic Acid (0.5%)	2.24
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + L-Tartaric Acid (1.0%)	2.46
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + L-Lactic Acid (1.0%)	2.82
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + Succinic Acid (1.0%)	3.24
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + Succinic Acid (1.0%)	2.32
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + L-Lactic Acid (1.0%)	2.02
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + L-Tartaric Acid (1.0%)	1.58
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + Unipine 90 Acid (1.0%)	5.12
Sodium Salicylate (0.5%) + Caprylic Acid (0.5%) + Adipic Acid (1.0%)	2.78
Caprylic Acid (1.0%) + Gluconic Acid (0.5%)	2.49
Caprylic Acid (1.0%) + Succinic Acid (0.5%)	2.29
Caprylic Acid (1.0%) + Beta-Alanine (0.5%)	4.4
Caprylic Acid (1.0%)	3.85
Caprylic Acid (1.0%) + L-Tartaric Acid (0.5%)	1.76
Caprylic Acid (1.0%) + L-Lactic Acid (0.5%)	1.95
L-Tartaric Acid (0.5%)	1.72
Beta-Alanine (0.5%)	6.65

**Example 57****Field trial comparisons of caprylic/capric and pelargonic acids  
on mixed weed varieties**

<u>Treatment</u>	<u>Average injury rating per plot*</u>
1 3% caprylic/capric	3.95
2 3% caprylic/capric + 0.75% succinic acid	4.113
3 3% pelargonic	4.175
4 3% pelargonic + 0.75% succinic acid	4.213

\* A rating of 1-5 given for each of 2 plots per treatment group where 5 was complete desiccation of all plants

Plot size: 6 X 9.3 feet

Weed varieties: grasses (dominant), dandelion, pigweed, plantain and Canadian thistle

Summary: addition of succinic acid was beneficial



**Example 58****Field trial comparisons of caprylic/capric and pelargonic acids on mixed weed varieties**

Canadian thistle:		Average injury rating per plot*
Treatment		
1	3% caprylic/capric	2.58
2	3% caprylic/capric + 0.75% succinic acid	2.8
3	3% pelargonic	4.03
4	3% pelargonic + 0.75% succinic acid	4.35

  

Redwood pigweed:		Average injury rating per plot*
Treatment		
1	4% caprylic/capric	3.1
2	6% caprylic/capric	4.55
3	6% pelargonic	4.35

\* A rating of 1-5 given for each of 2 plots per treatment group where 5 was complete desiccation of all plants  
Plot size: 6 X 9.3 feet

Summary: 1) although pelargonic acid was more effective for C. Thistle, caprylic/capric performed best on redroot pigweed, 2) addition of succinic acid was effective

**Example 59**

**Succinic Acids Potentiation of Sodium Salicylate,  
Testing Cotton  
Treatment effect 2 days after a single, foliar application**

<u>Treatment</u>	Foliage <u>Affected (%)</u> No effect
Succinic Acid (1.0%)	
Succinic Acid (1.0%) + Sodium Salicylate (1.0%)	>70
Sodium Salicylate (1.0%)	<70
Some foliage (all treatments except succinic acid, alone) beginning to drop	

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above methods and in the compositions set forth, without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

It is also understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language might be said to fall therebetween.

Particularly, it is to be understood that in said claims, ingredients or components recited in the singular are intended to include compatible mixtures of said ingredients wherever the sense permits.

## CLAIMS

What is claimed is:

1. A herbicidal composition, comprising: a fatty acid of a type and in an effective amount to provide a herbicidal effect when applied to a plant and an additive, having substantially no herbicidal effect on the plant in the absence of the herbicide, but which increases the herbicidal effect of the composition on the plant beyond that of the composition without the additive.
2. The composition of claim 1, wherein the fatty acid herbicide includes at least one member selected from the group consisting of pelargonic acid, caprylic acid, caproic acid, capric acid, oleic acid, acetic, butyric acid, valeric acid, hexanoic acid and heptanoic acid.
3. The composition of claim 1, wherein the fatty acid herbicide includes at least one member selected from the group consisting of pelargonic acid, caprylic acid, caproic acid, capric acid and oleic acid.
4. The composition of claim 1, wherein the fatty acid herbicide includes at least one member selected from the group consisting of acetic, butyric acid, valeric acid, hexanoic acid and heptanoic acid.
5. The composition of claim 1, wherein the fatty acid herbicide comprises caprylic acid and/or pelargonic acid.
6. The composition of claim 1, wherein the additive includes at least one member selected from the group consisting of succinic acid, succinic acid derivatives, tartaric acid, citric acid, malic acid, lactic acid, adipic acid, pine oil derivatives,

limonene, ammonium tartrate, ammonium chloride, ammonium sulfate and sodium salicylate.

7. The composition of claim 1, wherein the additive includes a member selected from the group consisting of succinic acid, dimethyl succinic acid, calcium succinate, magnesium succinate, diammonium succinate and ammonium succinate.

8. The composition of claim 1, wherein the additive includes at least one member selected from the group consisting of tartaric acid, citric acid, malic acid, lactic acid, adipic acid and pine oil derivative, limonene and derivatives thereof.

9. The composition of claim 1, wherein the additive includes at least one member selected from the group consisting of ammonium tartrate, ammonium chloride and ammonium sulfate.

10. The composition of claim 1, wherein the herbicide and additive comprise 0.1 to 30% of the composition.

11. The composition of claim 1, wherein the ratio of herbicide to additive is 1:10 to 20:1.

12. The composition of claim 1, wherein the herbicide and additive comprise about 0.5 to 15% of the composition in a ratio of about 1:1 to 20:1.

13. The composition of claim 1, wherein the additive comprises succinic acid and the herbicide comprises pelargonic acid and/or caprylic acid.

14. A method of enhancing the herbicidal activity of an organic herbicide, comprising adding to the herbicide an effective amount of an additive having substantially no herbicidal activity and thereby increasing the herbicidal activity of the herbicide.

15. The method of claim 14, wherein the additive includes a member selected from the group consisting of succinic acid, limonene, pine oil derivatives, succinic acid derivatives, tartaric acid, citric acid, malic acid, lactic acid, adipic acid, ammonium tartrate, ammonium chloride and ammonium sulfate.

16. The method of claim 14, wherein the additive includes succinic acid.

17. The method of claim 15, wherein the ratio of herbicide to additive is about 1:1 to 5:1.

18. A method of controlling plant growth, comprising: applying to plants a herbicidally effective amount of a herbicidal composition comprising a fatty acid of a type to provide a herbicidal effect when applied to a plant and an additive, having substantially no herbicidal effect on the plant in the absence of the herbicide, but which increases the herbicidal effect of the composition on the plant beyond that of the composition without the additive.

19. The method claim 18, wherein the fatty acid herbicide includes at least one member selected from the group consisting of pelargonic acid, caprylic acid, caproic acid, capric acid, oleic acid, acetic, butyric acid, valeric acid, hexanoic acid and heptanoic acid and the additive includes at least one member selected from the group consisting of succinic acid, succinic acid derivatives, tartaric acid, citric acid, malic acid, lactic acid, adipic acid, pine oil derivatives, limonene, ammonium tartrate, ammonium chloride, ammonium sulfate and sodium salicylate.

20. The method of claim 18, wherein the herbicide comprises pelargonic and/or caprylic acid and the additive comprises succinic acid.

21. A herbicidal composition, comprising sodium salicylate and an additive selected from the group consisting of succinic acid, succinic acid derivatives, tartaric acid, citric acid, malic acid, lactic acid, adipic acid, pine oil derivatives, limonene, ammonium tartrate, ammonium chloride, ammonium sulfate and combinations thereof.

22. The composition of claim 21, wherein the additive comprises succinic acid.

23. A herbicidal composition, comprising glufosinate-ammonium or glyphosate and an additive selected from the group consisting of succinic acid, succinic acid derivatives, tartaric acid, citric acid, malic acid, lactic acid, adipic acid, pine oil derivatives, limonene, ammonium tartrate, ammonium chloride, ammonium sulfate and combinations thereof.

24. The composition of claim 23, wherein the additive comprises succinic acid.

## INTERNATIONAL SEARCH REPORT

 International application No.  
PCT/US00/28405

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A01N/ 59/00, 57/00, 63/00, 37/00, 37/08

US CL : 504/118, 125, 127, 142, 144

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 504/118, 125, 127, 142, 144

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WEST

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,035,741 A [PURITCH et al] 30 July 1991, abstract, col. 1, lines 50-69, col. 2, lines 48-65, col. 3, lines 1-59, col. 7 lines 35-48.	1,14,18
X	US 5,573,997 A [LOJEK et al] 12 November 1996, abstract, col. 1, lines 25-44, col. 2, lines 4-22.	1,2,4,8,14,15,18,19
Y	WO 9747199 A [AUDA et al] 18 December 1997, abstract.	1-3,5,6,10 - 12,14,15,17-19
Y	JP 07157406 A [MOCHIZUKI et al] 20 June 1995, abstract.	1-3,5,6,10 - 12,14,15,17-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

30 NOVEMBER 2000

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26 MAR 2001

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US00/28405

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SU 1209221 [SKLYAR et al] 7 February 1986, abstract.	21
Y	EP 0577914 A [KHAN et al] 01 December 1994, abstract, claim 1.	23
Y	US 4,994,273 A [ZENTNER et al] 19 February 1991, col. 4, lines 15-60, col. 6, lines 41-58, claim 1.	23

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